A TAXONOMIC STUDY OF AMPHIBIANS AND REPTILES OF THE CENTRAL HIGHLANDS OF NEW GUINEA, WITH NOTES ON THEIR ECOLOGY AND BIOLOGY

2. ANURA : Ranidae and Hylidae

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[Read 12 April 1962]

SUMMARY

In the present paper two new species, *Hyla micromembrana* and *Hyla mintima*, are described and of the thirteen Hylidae included two additional species are new records for the Central Highlands of New Guinea. Observations on *Rana grisea* van Kampen, the only representative of the Ranidae found in this region, are also recorded.

The tadpoles of *Hyla angularis* Loveridge, *H. darlingtoni* Loveridge and *H. iris* Tyler are described, of which the first-mentioned is shown to be structurally adapted to montane conditions in a manner previously associated solely with *Nyctimystes* spp., and the spawn and early development of *H. iris* is reported. Notes on habitat, diet, call, parasites and habits are included, and native vernacular names listed. Distribution is discussed, and eight species are shown to be endemic to the Central Highlands. The record of *N. humeralis* (Boulenger) from this region is excluded from the check list prepared as it probably refers to another species; the current recognition of *N. flavomaculata* Forcart as a synonym of *H. darlingtoni* is supported, and *H. pratti* Boulenger is restored to specific status.

It is tentatively suggested that the position of the proximal margin of the nuptial pad may provide a further method for distinguishing male *Nyctimystes* from *Hyla*.

INTRODUCTION

The amphibians of the Central Highlands of the Australian Trusteeship Territory of New Guinea represent the Anuran families Ranidae, Hylidae and Microhylidae. The first paper describing the herpetofauna of this isolated region was written by Loveridge and published as recently as 1945. Since that date the Microhylidae has been the subject of most attention (Zweifel, 1956, 1956a, 1962; Tyler, 1962d).

Of the six species of *Rana* currently recognised from New Guinea, only one, *R. grisea* van Kampen, has been found in the Central Highlands. Loveridge (1948) commented upon four specimens collected at Kundiawa in 1944, and Forcart (1953) stated that two had been taken at Mingende in 1949.

The Hylidae inhabiting the Central Highlands are members of the genera *Hyla* and *Nyctimystes*. Loveridge (1945) described *H. angularis*, *H. becki* and *H. darlingtoni*; Forcart (*loc. cit.*) listed *H. arfakiana* Peters and Doria, and *H. angiana* Boulenger, and described *N. flavomaculata*. More recently Zweifel (1958) in revising the genus *Nyctimystes* recorded *N. papua* (Boulenger) and

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N. humeralis (Boulenger), and described *N. kubori* and *N. narinosa*, whilst the writer has described *H. iris* (1962a).

The present paper is the second of a series on the herpetofauna of the Central Highlands of New Guinea. It is concerned with the results of a survey conducted in the vicinity of Nondugl in the Wahgi Valley, during the period January-July, 1960, and taxonomic studies at the British Museum (Natural History) during the corresponding period in the following year. Geographical and ecological notes, and a sketch map of the Wahgi Valley in the vicinity of Nondugl are included in the first paper in the present series (1962d). Details of the rainfall recorded at Nondugl are illustrated in the form of a graph in Fig. 1.

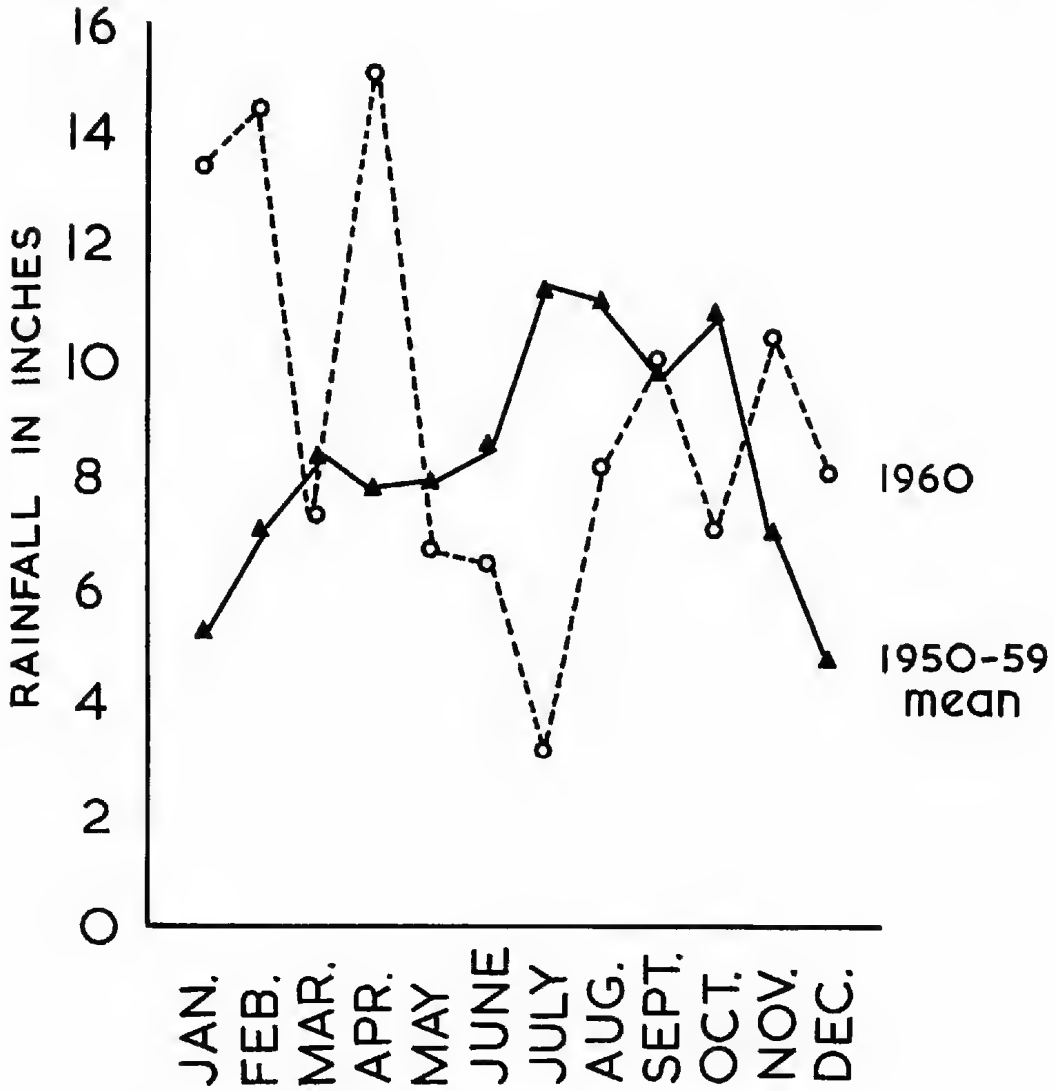

Fig. 1. Rainfall in Central Highlands. (Prepared from data obtained by the Hallstrom Livestock and Fauna Station, Nondugl.)

MATERIALS AND METHODS

Materials used and methods of measurement of specimens closely follow those previously employed for the Microhylidae. The ratio of the distance between eye and naris to internarial distance is abbreviated as E-N/IN, and tibia length to snout to vent length at TL/S-V.

Sex was determined by the presence of secondary sexual characters in males and by dissection in the case of females.

The abbreviations of the names of institutions where the collection has been lodged are as follows:

A.M.N.H. = American Museum of Natural History, New York.
Austral Mus. = Australian Museum, Sydney.
B.M. = British Museum (Natural History), London.
K.T.C. = Kingston Technical College, Kingston-upon-Thames, England.
S.A.M. = South Australian Museum, Adelaide.

SPECIES REPRESENTED

Family RANIDAE

Rana grisea van Kampen

Rana grisea van Kampen, 1913, *Nova Guinea*, 9, p. 460.

Material: 33 specimens (unsexed)—Austral. Mus. R.16808-16815, B.M. 1961.806-830.

Description: Distance between thickened dorso-lateral folds immediately behind eyes slightly greater than (19 specimens), or equal to (14), distance from external nares to posterior border of eye; tympanum approximately ⅝ diameter of eye, from which it is separated by a distance of approximately ⅔ of its own diameter. Adpressed heel reaches external nares (7), between external nares and tip of snout (9), or beyond tip of snout (17); toes fully webbed except for fourth which has only a narrow fringe on terminal two joints.

Body length: 22·6-80·4 mm.

Colour in life: Dorsally and laterally a uniform pale brown with a metallic greenish-gold tint (14). A dark brown patch (24) extends from tip of snout to just posterior to tympanum, descending from canthus rostralis to margin of upper lip; tympanum obscured by this patch (28) or flecked with gold (5). A few clearly defined black spots above the eye and less prominent ones posterior to it. Dorso-lateral glandular folds paler than ground colour in juveniles, but merge with it in adults. Three or four bars on upper surface of thighs become darker, and assume a bluish tint in adults.

Ventral surface of body and forelimbs grey (3), cream (24), pale pink (4) or pale green (2), becoming obscured by chocolate patches as specimens reach sexual maturity. Ventral surface of hindlimbs pink in adults. In small juveniles abdomen and thighs are a brilliant yellow. By the time a body length of 40 mm. has been attained, the yellow has become much paler and less extensive anteriorly. At 50 mm. it is restricted to posterior 5 mm., and indistinct patches on thighs. By 60 mm. the yellow markings have completely disappeared.

Locality: Thirty-two specimens were collected between 26.3.60 and 24.4.60 in long grass beside ditches on the Hallstrom Livestock and Fauna Station at Nondugl, and one from a creek named Mingende, at a village of the same name, in the Chimbu region, on 1.6.60.

Remarks: Specimens of *R. grisea* have occasionally been mistaken for *R. papua* Lesson. A brief key to distinguish these species was prepared by Parker (1936), who stated that the distance between the dorso-lateral, glandular skin folds on the occiput of *R. papua* is, "scarcely, if at all, greater than the distance between the nostril and the posterior corner of the eye". In *R. grisea* the distance between the folds is "as great as the distance from the nostril to the tympanum".

The present series of specimens agrees with the above diagnosis of *grisea*, but none approach the maximum snout-vent lengths recorded: ♂ ♂ 80 mm., ♀ ♀ 120 mm.

Development: The number of ripe ova dissected from two gravid females totalled 620 and 622 respectively.

The mouthparts of tadpoles referred to *R. grisea* by Parker (*loc. cit.*) possess three upper rows and three lower rows of labial teeth, of which the innermost two of the upper are widely divided in the midline. The tadpoles of *R. papua* are described by Parker to have four or five rows of upper labial teeth, and three rows of lower labials.

Diet: Stomach contents included large beetles of the families Curculionidae and Carabidae; Orthoptera (Acrididae), Lepidopterous larvae and adult moths and millipedes.

Notes: The native name most commonly applied to this species is "*Gem-boogal*". Occasionally it is called "*Missil*".

Specimens of *Rana grisea* in the British Museum collection include a series collected at Minj in the Wahgi Valley by Mr. F. M. Shaw Mayer in 1952 (B.M. 1953.1.7.36-46).

Family HYLIDAE

Nyctimystes kubori Zweifel

Nyctimystes kubori Zweifel, 1958, *Amer. Mus. Novit.*, 1896, p. 18.

Material: 17 ♂ ♂, 1 ♀, 2 juveniles — A.M.N.H. 67616-67619; Austral. Mus. R.16831, 16853, 17589-17592; B.M. 1961. 1155-1164.

Description: The present series conform closely to the recent description. The TL/S-V and E-N/IN ratios of the males are tabulated in Table 1.

Body Length: Juveniles 19·8-21·1 mm.; ♂ ♂ 38·3-47·0 mm.; ♀ 56·0 mm.

In life the eyes are prominent, the iris is blue-black and the shape of the pupil circular, elliptical or vertical. Male with vocal sacs, which are apparently internal communicating with mouth by paired slits at side of tongue, and rugose nuptial pads. The nuptial pad of B.M. 1961. 1163 is illustrated in Fig. 2.

The colour of the dorsal surface of the body is pale brown with patches of grey, orange or black, or any combination of these colours, upon it. The ventral surface is pale pink.

Locality: Twelve specimens were taken from low herbage in moss-forest at 6,300 ft. near Bilikep, on the Wahgi-Sepik Divide on 26.3.60. A further six were collected at Bamna at the foot of the Divide on 16.4.60, and the remaining two specimens at the same locality on 24.4.60.

Remarks: *Nyctimystes kubori* shares certain similarities of proportions with *N. humeralis* (Boulenger), but the males lack the humeral spine which is characteristic of male *N. humeralis*, and do not exhibit immaculate green dorsal colouration of that species.

N. kubori has hitherto been known solely from the holotype and two paratypes, which are all gravid females, and a juvenile tentatively referred to it.

Notes: The native name of *N. kubori* is "*Deg-eh*".

One of the juveniles (B.M. 1961. 1161) was found to be infested with a small leech, situated subcutaneously beneath the ventral surface in the pectoral region. A note on the endoparasitic infestations by leeches of this and other species of New Guinea frogs will be the subject of a future publication.

The specific name was based upon that of the type locality: the Kubor Mountains.

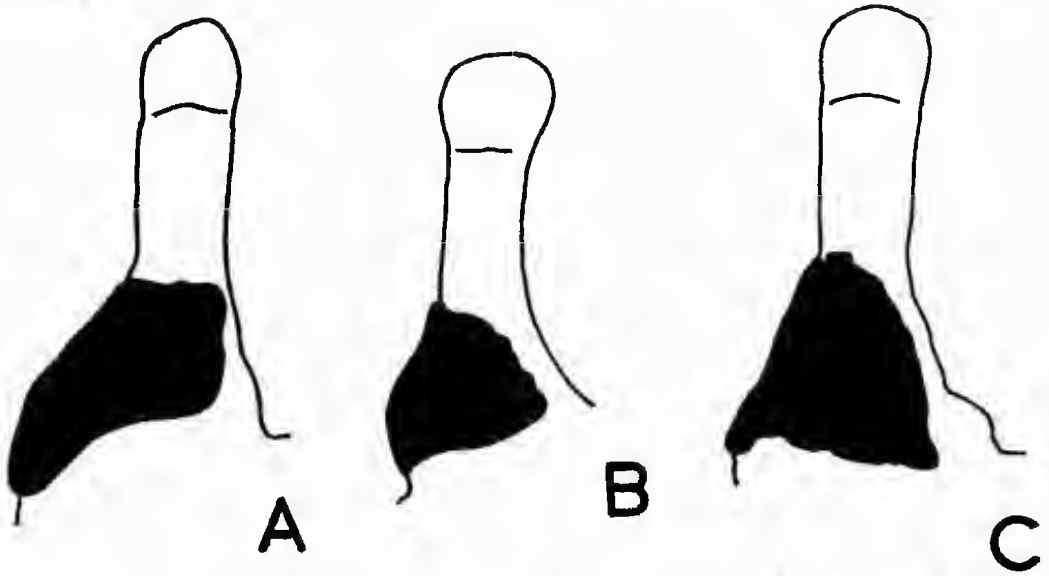

Fig. 2. Nuptial pads of *Nyctimystes*. A = *N. narinosa* (B.M. 1961.1151); B = *N. kubori* (B.M. 1961.1163); C = *N. papua* (B.M. 1961.1124).

Nyctimystes narinosa Zweifel

Nyctimystes narinosa Zweifel, 1958, *Amer. Mus. Novit.*, 1896, p. 26.

Material: 5 adult ♂ ♂, 2 adult ♀ ♀, Austral. Mus. R. 16830, 17635, 17636; B.M. 1961. 1151-1154.

Description: The present series agree so closely with the recent description by Zweifel (1958), that the inclusion of an account of their morphological characteristics would only be an unnecessary repetition. The E-N/IN and TL/S-V

ratios are compared with those of the type series in Table 1. The male possesses a nuptial pad on the first finger as depicted in Fig. 2, the pupil shape is a horizontal slit in life.

Body Length: 55·5-59·8 mm., 54·0-69·8 mm.

Dorsal and lateral surfaces of body and limbs a dark grey, with large, irregularly shaped patches of cream upon them. Dorsal and lateral surface of limbs uniform grey, with small, white tubercles upon posterior surface of forearm.

Ventral surface of body and limbs a light shade of grey. Granular surface of lower abdomen and thighs stippled with black.

Locality: One specimen was taken from low herbage on the summit of a pass (9,500 ft.) on the Wahgi-Sepik Divide near Banz on 28.5.60. Five more were taken in dense moss-forest at 8,700 ft. on Mt. Odan, ten miles east, on 9.6.60, and a further specimen at 10,500 ft. on the same day.

Remarks: When comparing *N. narinosa* with other species, Zweifel pointed out that the shape of the snout and reduced webbing of the fingers was similar to *N. papua* (Boulenger) and *N. gularis* Parker, but stated that they could be differentiated from these species by the form of the palpebral venation. Although the writer's examination of the types of *N. gularis* confirm the distinction of *N. narinosa* from that species (Tyler, 1962c), the pattern of the palpebral venation of the former is quite unlike Zweifel's figure and definition, whilst the results of an examination of the types of *N. papua* indicate that not all the members of the type series are conspecific. (Discussed in the account of that species.)

TABLE 1.

A comparison of tibia length to snout to vent length (TL/S-V), and of eye to naris distance to internarial distance (E-N/IN) between the present series of *Nyctimystes* and the types.

	TL/S-V		E-N/IN	
Species	Mean	Range	Mean	Range
kubori	0·578	0·54-0·61	1·03	0·91-1·14
kubori types	0·539	0·51-0·57	1·05	0·94-1·14
narinosa	0·564	0·54-0·61	0·87	0·84-0·92
narinosa types	0·563	0·54-0·61	0·84	0·79-0·93
papua	0·550	0·51-0·58	0·93	0·86-0·98
papua types	0·567	0·56-0·58	0·89	0·85-0·96

In the British Museum collection are two specimens described as "*Nyctimystes* sp. near *gularis*" (B.M. 1953. 1.7.47-48), which the writer refers to *N. narinosa*. The specimens were collected at Tomba (8,000 ft.), at the southern end of the Mt. Hagen range, by F. M. Shaw Mayer in February, 1951.

Distribution: *Nyctimystes narinosa* has only been recorded from the Mt. Hagen region and the mountains bordering the Wahgi Valley.

Notes: The occurrence of an endoparasitic infestation of leeches was observed in two specimens.

The native name of this frog is "*Kork*".

Nyctimystes papua (Boulenger)

Nyctimantis papua Boulenger, 1897, *Ann. Mag. nat. Hist.*, 6, 19, p. 12.

Material: 16 adult ♂♂, 13 adult ♀♀ — Austral. Mus. R.16816-16821; B.M. 1961. 1103-1125.

Description: The present series agrees very well with the redescription of Zweifel (1958). The E-N/IN and TL/S-V ratios are tabulated in Table 1. The pupil is vertical in life.

Body Length: ♂♂ 57·8-66·9 mm.; ♀♀ 67·9-73·8 mm.

In life the dorsal and lateral surfaces of head, body and limbs are densely flecked with metallic greenish-gold and black (18 specimens), or with deep violet and black (11); ventral surfaces pale grey replaced by violet of a variety of shades, particularly upon the posterior portion of the body and hindlimbs. Throat crimson in three specimens. Palmar and plantar surfaces grey.

The appearance of the male nuptial pad is depicted in Fig. 2.

Locality: Collected on Wahgi-Sepik Divide at elevations between 6,300 ft. and 7,500 ft. within the vicinity of Nondugl during the period 28.3.60-24.4.60.

Examination of Type Specimens: The British Museum type series (B.M. 96.10.31.50-53) originally consisted of five specimens, but Parker (1936) excluded one which had quite distinctive characteristics and tentatively referred it to *N. semipalmata* Parker.

After an additional re-examination of the remaining cotypes, the writer is of the opinion that the series is still not conspecific. Since the cotypes are all females and have been catalogued as a series, it is necessary for purposes of comparison that each be readily identifiable as an individual specimen, and they are therefore referred to as A, B, C and D respectively. The measurements of these specimens are tabulated in Table 2.

TABLE 2.

Measurements of cotypes of *Nyctimystes papua* in the British Museum

Ref.	E-N	IN	E-N/IN	TL	S-V	TL/S-V
A	4·3	5·0	·860	31·0	53·9	·575
B	4·4	4·6	·957	30·8	54·0	·570
C	5·8	5·7	1·018	38·2	63·0	·606
D	4·4	5·2	·846	35·6	63·9	·556

Specimens A and B are almost identical in size and appearance and differ mainly in the E-N/IN ratios. They share with C and a cotype in the Museum of Comparative Zoology at Harvard (M.C.Z. 12838) a palpebral venation which, as defined by Parker, "is reduced to a few scattered dots and indefinite lines". Specimen D, however, possesses a well-developed palpebral venation, forming an almost complete reticulum whose orientation is almost horizontal. A further difference between D and the other British Museum cotypes is that the tympanum is completely free, whereas in the remainder the superior margin is hidden beneath the supra-tympanic fold. The latter characteristic is apparently common to all of the 75 specimens of this species in the British Museum and the American Museum of Natural History. On the basis of the above characteristics D is regarded as distinct from *N. papua* but, although possessing a dermal appendage on the heel it cannot be referred to *N. semipalmata*.

Specimen C is excluded on the grounds that whereas the dorsal surface of A, B and all other known specimens is deep slate and granular, that of C is pale brown and strongly rugose. A further difference between this specimen and the other cotypes is that the distance between eye and naris is greater than the internarial distance, as opposed to being less than it.

The position of the vomerine teeth in relation to the choanae is at variance in the remaining cotypes. In A they are directly between the choanae and on a level with them, but in B they are below and behind them.

Until A and B are directly compared with M.C.Z. 12838, designation of a lectotype is considered premature.

Notes: This species is called "*Aynak*" by natives throughout the entire Wahgi Valley.

Ova dissected from a gravid female measured up to 3·3 mm. in diameter and were unpigmented.

Hyla angiana Boulenger

Hyla angiana Boulenger, 1915, *Ann. Mag. nat. Hist.*, 8, 16, p. 402.

Material: 8 adult ♂ ♂, 8 adult ♀ ♀ — Austral. Mus. R.17638-17641; B.M. 1961. 1165-1175.

Description: Head depressed, breadth greater than length; snout rounded; canthus rostralis distinct; loreal region concave; length of snout greater than diameter of eye; tympanum distinct, but superior border hidden by pronounced supra-tympanic fold extending from corner of eye to shoulder; tympanic diameter less than half that of eye. Vomerine teeth in two oblique series between posterior margins of choanae. Fingers one-third webbed, fourth toe webbed to sub-articular tubercle of penultimate phalanx, continuing to disc as a fringe; other toes fully webbed to discs; sub-articular tubercles prominent. Tibio-tarsal articulation of adpressed hind limb reaches tip of snout. Skin of dorsal surface smooth, ventral surface coarsely granular. Males possess vocal sacs and nuptial pads. Pupil horizontal in life.

Body length: ♂ ♂ 43·7-56·0 mm. (mean, 48·3 mm.); ♀ ♀ 66·8-77·5 mm. (mean, 72·3 mm.).

Colour in life of dorsal surface green (two specimens), green blotched with black (7), or green with black markings concentrated upon head and mid-dorsal regions (9). Canthus rostralis and side of head green (3), canthus rostralis brown and side of head green (8), or both brown (7). Upper lip bordered by broken white line. Lateral body surfaces green, becoming obscured by violet spots on ventro-laterals. Thorax and abdomen violet (5); lilac (7) or cream (6), throat of latter violet. Limbs green above, similar to colour of thorax beneath. Upper surfaces of discs pale green above, grey beneath. Above anus is a broad cream line (11), and white tubercles are situated beneath the anus of all specimens. Posterior surfaces of limbs are bordered with white (11).

Locality: Series taken from leaves of bushes near streams on Wahgi-Sepik Divide, within a five-mile radius of Nondugl, during the period 26.3.60-28.5.60. Altitude range from 6,300 ft. to 7,500 ft.

The present series compare favourably with the five cotypes in the British Museum collection (1915.9.10.11-15 = 1947.2.30.95-98), but show greater variation in the colour pattern.

Boulenger (1915) described the toes to be "webbed to the discs", as indicated in the figure accompanying his description, but examination of the cotypes revealed that the webbing of the penultimate phalanx of the fourth toe is only a narrow fringe.

Boulenger mentioned the apparent affinities of *H. angiana* to the group of *Hyla* species that he had previously allied to *H. caerulea* White, and drew attention to the small size of the tympanum shared by *H. humeralis* Boulenger. The last-mentioned species has subsequently been transferred to the genus *Nyctimystes* on the grounds of its possession of a vertical pupil and palpebral venation (Zweifel, 1958), and their affinities appear more remote.

Comparison of the present series with an account of the morphological characteristics of *H. arfakiana* Peters and Doria by Loveridge (1948), led to an initial supposition that the present series included representatives of that species. Examination of the British Museum cotypes of *H. arfakiana* (B.M. 82.10.3.3-5) and the original description (1878), enabled their distinction from that species to be more readily determined.

Amplexus: Three pairs were found in amplexus:

Austral. Mus. R.17630 ♂	×	B.M. 1961.1165 ♀	(28.3.60)
B.M. 1961.1170 ♂	×	B.M. 1961.1171 ♀	(24.4.60)
B.M. 1961.1175 ♂	×	B.M. 1961.1174 ♀	(24.4.60)

The male amplexal grasp was supra-axillary, with the fourth finger upon the superior surface of the humerus, and the remaining fingers pressed against its posterior surface.

A male *H. angiana* was also take in amplexus with a female *Rana grisea* (Austral. Mus. R.16810). The pair were collected on 26.3.60, and remained in this position for eight days. Ovulation was not induced during this period.

Distribution. This species is known from specimens on and around the Arfak Mountains in Dutch New Guinea, and has previously been recorded in the Wahgi Valley by Forcart (1953). Altitude range: 5,000-8,000 ft.

Notes: Food items recovered from stomachs consisted of Diptera, Orthoptera and moss.

The bladders of two specimens were found to be infested with Trematodes.

The specific name was based upon the name of the type locality: the Angi Lakes in the Arfak Mountains, whilst the native vernacular name is "*Kownar*".

Hyla angularis Loveridge

Hyla angularis Loveridge, 1945, *Proc. biol. Soc., Wash.*, 58, p. 54.

Material: 16 ♂♂, 3 ♀♀, 1 tadpole – Austral Mus. R.16857-16859; B.M. 1961.1228-1242, 1243 (tadpole).

Description: Vomerine teeth in two short, oblique series directly between the oval choanae, separated from each other by a distance slightly greater than the length of one series; tongue slightly more than half the width of mouth opening, oval, its posterior border free and slightly notched; snout elongated and depressed, pointed or rounded when viewed from above, tip slightly concave in profile, the upper jaw extending beyond lower; nostrils more lateral than superior, considerably projecting, their distance from end of snout very slightly less than that from eye. Canthus rostralis angular and extremely prominent; loreal region concave and oblique, the upper lip flaring out strongly

below it. Eye large, its diameter slightly greater than its distance from naris, inter-orbital distance greater than the width of upper eyelid, and less than internarial distance. Pupil horizontal in life. Tympanum distinct, its superior border hidden beneath strong supratympanic fold which extends from posterior

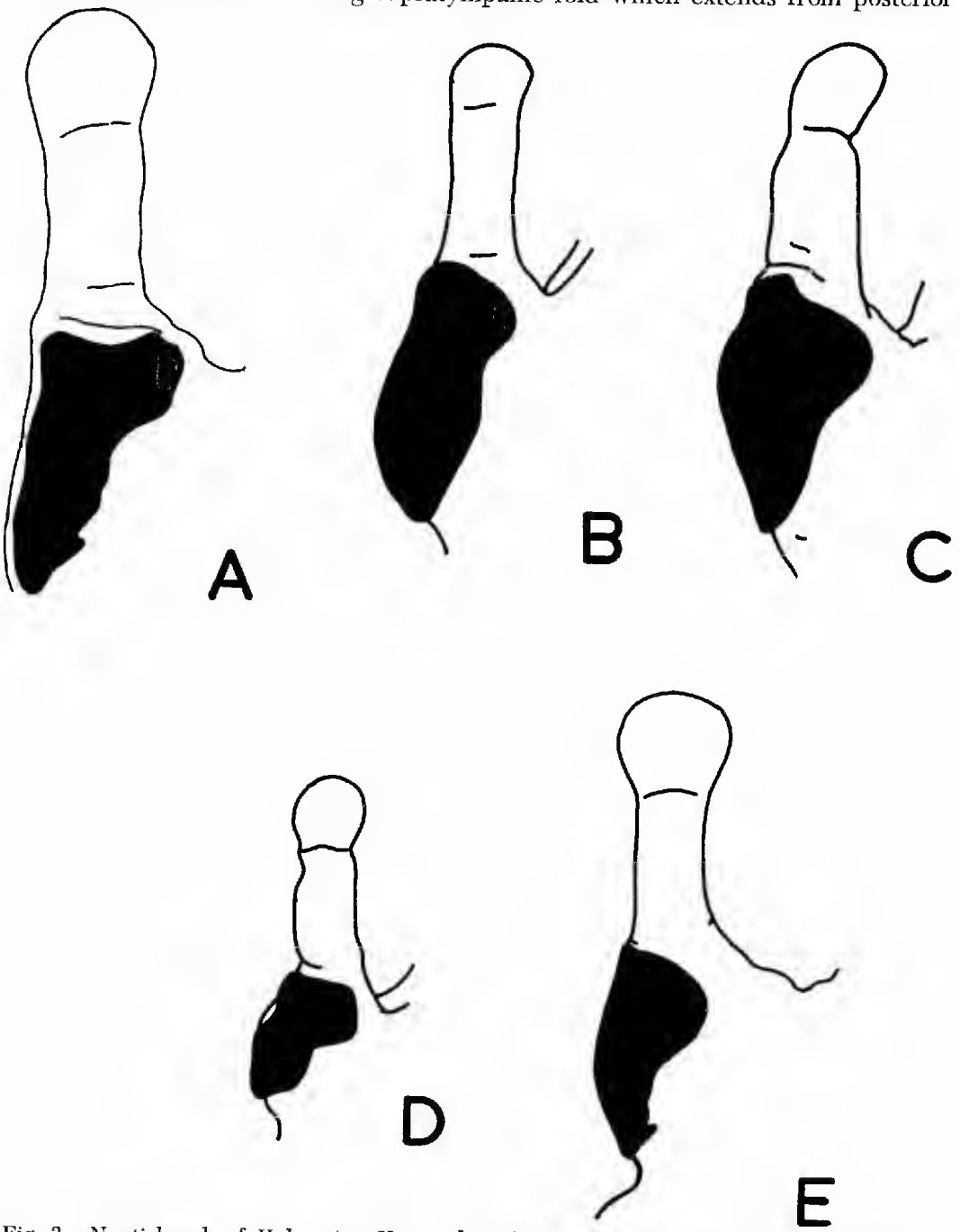

Fig. 3. Nuptial pads of *Hyla*. A = *H. angularis* (B.M. 1961.1242); B = *H. montana* (B.M. 1962.152); C = *H. mintima* Holotype S.A.M. R.4151); D = *H. becki* (S.A.M. R.4142); E = *H. darlingtoni* (B.M. 1961.1134).

corner of eye to shoulder; tympanum separated from eye by a distance nearly equal to its own diameter. First two fingers webbed at base or one-third webbed, fourth considerably longer than second, just reaching to disc of third which is almost equal to size of tympanum; distinct oval inner metacarpal tubercle. First, second and fifth toes webbed to disc, fourth to sub-articular tubercle of penultimate phalanx, and third to point midway between penultimate phalanx and disc; disc of fourth slightly smaller than tympanum. Inner but no outer metatarsal tubercle; no tarsal ridge; very small, conical, dermal appendanges on heel, usually two in number.

Body not elongate, in post-axillary region a little narrower than greatest width of head; when hind limbs adpressed, heel reaches beyond tip of snout; when limbs are laid along the sides, knee and elbow considerably overlap; when limbs are bent at right angles to body, heels overlap greatly. A narrow patagium extends from the back of the upper arm to the side of the body. Skin of upper parts non-glandular, with few scattered conical tubercles on dorso-lateral surfaces of body, and on posterior half of upper eyelid; large tubercles around anus; skin of thorax smooth, throat lightly granular, abdomen and lower femur coarsely granular; skin of head not co-ossified with skull, roof of skull not exostosed. Male with vocal sac which is apparently internal, with paired openings in floor of mouth at angles of jaws; nuptial pad on inner surface of first finger as depicted in Fig. 3. TL/S-V = ·569-·664 (mean = ·616).

Body length: 33·1-42·1 mm. ♂ ♂; 47·6-52·9 mm. ♀ ♀.

Dorsal surface of head, body and limbs grey or pale brown, very lightly flecked with small black spots; lateral body surfaces and thighs slightly paler than ground colour. Ventral surface white or cream marbled or variegated with grey or black. Tubercles around anus white. No appreciable change between colour in life and that in alcohol.

Locality: The series was collected at various localities on the Wahgi-Sepik Divide, during the period 26.3.60-4.4.60 at altitudes of 6,000 ft. to 6,500 ft.

Remarks: Miss A. G. C. Grandison of the British Museum (Natural History) kindly compared the present series with a paratype lent by the Museum of Comparative Zoology, Harvard, and reported that the majority differ from it in few respects. The skin of *H. angularis* is described as smooth, but low power microscopic examination revealed small tubercles. The skin of the present series is sparsely tuberculose, and the tubercles are prominent macroscopically. It has been suggested that large tubercles might be a characteristic associated with the breeding season.

The description of the colouration of the type series differs markedly from the present series. Loveridge described the colour in preservative as blue-black dorsally, and referred to a broad rostro-lateral stripe. These features are not exhibited by the Wahgi-Sepik Divide material.

When mentioning the affinities of *H. angularis*, Loveridge stated that in van Kampen's key (1923) it came near to *H. everetti* Boulenger of the Dutch East Indies, but differed from it in many respects. The cotypes of *H. everetti* lodged in the British Museum (B.M. 97.6.21. 104-111 = 1947.2.23. 60-67) have been examined by the writer and the distinction from *H. angularis* confirmed.

Development: The early stages of development are unknown, but large tadpoles, clearly referable to this species by the characteristic shape of the angular canthus rostralis and tip of the snout, were collected from beneath

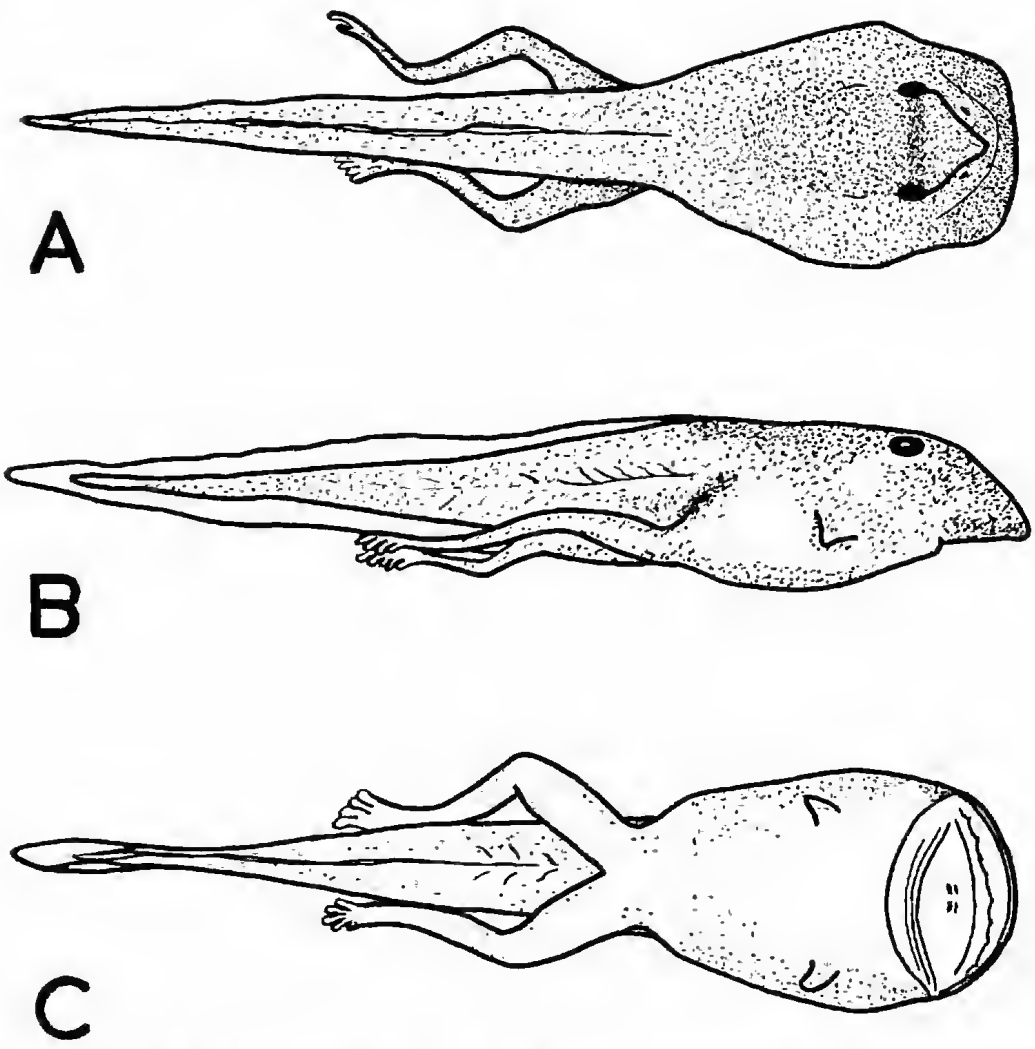

Fig. 4. Tadpole of *Hyla angularis*. B.M. 1961.1243. A = dorsal surface; B = lateral; C = ventral.

flat stones in a stream on Mt. Pipening at 6,500 ft. on 9.5.60. Figures of one of these specimens are depicted in Fig. 4.

The tadpoles are structurally adapted to an environment where they are subjected to fast-flowing water. The body is flattened dorso-ventrally, and the large ventral, suctorial mouth enables the tadpole to obtain a purchase on the smooth undersurface of flat stones. The labial teeth and horny beak are highly specialised, and are believed to function in such a way that the tadpole is able to feed whilst yet maintaining its hold. The mouth is depicted in Fig. 5 and the following is a description of the mouthparts:

The first and second rows of upper labial teeth are complete rows. Those of the second row are far longer than the first, and each individual tooth is of bicuspid form with tips projecting posteriorly and downwards. The horny beak

is reduced to two pairs of short rows of fused teeth, situated on either side of the midline. There are three complete rows of lower labials. The relative lengths of the teeth of the different rows is as follows (U.L. = upper labial; L.L. = lower labial): U.L.2 > L.L.1 > U.L.1 = L.L.3.

The tadpoles of this species were always found attached to stones in the manner described, and presumably feed upon the algae which inevitably coated the stones. The following explanation is the writer's opinion of their likely mode of action:

The horny beak of the tadpoles of most species of frogs inhabiting static or slowly moving water consists of two semi-lunar plates of fused teeth which are far larger in size than any of the rows of labials.

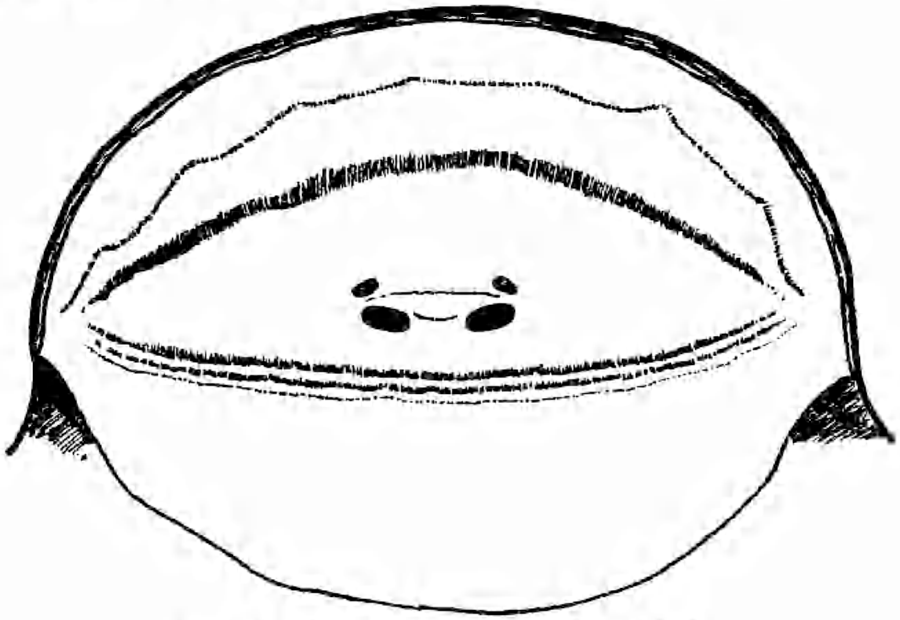

Fig. 5. Mouthparts of *Hyla angularis* tadpole.

In the tadpoles of *H. angularis* it is suggested that the second row of upper labials is responsible for the rôle normally undertaken by the horny beak. The latter, being situated more deeply within the mouth at the border of the pharyngeal region is structurally unsuited for rasping off a film of algae. Were the horny beak to play this rôle in *H. angularis* it would need to project far further forwards and, even then, only the medial portion would be functional. The more superficial site and greater mobility of the second row of upper labials presumably enable this row to rasp large portions of food from the stone without the tadpole losing purchase. The first row of upper labials may loosen the food medium, whilst the lower rows could act as a trap. The horny beak probably plays no part at all in feeding, but could effectively seal the opening to the oesophagus when the need to do so arose.

Smith (1927) figured the mouthparts of the tadpole of *H. everetti* and it is apparent that the tadpole of *H. angularis* bears no relationship with it.

Notes: The native names of *H. angularis* are "*Karga*" and "*Kuglam-balka*". The specific name of *angularis* refers to the characteristic angular form of the canthus rostralis.

Hyla becki Loveridge

Hyla becki Loveridge, 1945, *Proc. biol. Soc. Wash.*, **58**, p. 55.

Material: 33 ♂♂, 13 ♀♀ — Austral. Mus. R.17627-17634; B.M. 1961. 1176-1203; S.A.M. R.4142-4149.

Description: The present series agrees with the description of the type series in but a few respects. The males have a nuptial pad on the inner surface of the first finger (Fig. 3).

Body Length: 26·2-35·6 mm. ♂♂ (mean: 29·6 mm.); 32·0-37·1 mm. ♀♀ (mean: 34·6 mm.).

Colour in Life: Dorsal and lateral surfaces of body, limbs and head posterior to transocular region dark green with lighter patches; anterior portion of head pale green. Ventral surface of body lime, limbs similar, lightly stippled with grey.

Locality: Three specimens were taken in moss-forest on the Wahgi-Sepik Divide near Nondugl at 6,000 ft. on 26.3.60, and the remainder on the nearby Mt. Podamp at 7,500 ft. on 1.4.60.

Remarks: Loveridge's holotype, a 38 mm. male, is larger than any of the present series which, being taken at the height of the breeding season, would presumably include specimens of the maximum size attained. The females are larger than the males and several are gravid containing unpigmented ova approximately 2·5 mm. in diameter.

Direct comparison of the present series with the types will be necessary before it can be established whether there are any further differences not apparent from the original description.

Distribution: *Hyla becki* is only known from the type locality of Mt. Wilhelm where it was collected at 7,500-10,000 ft.

Notes: Two frogs (B.M. 1961.1204, 1205) with body lengths of 31·1 mm. and 27·4 mm. were found to be the hosts of leeches measuring 23·5 mm. and 23·8 mm. in length respectively. The leeches were situated subcutaneously on the dorsal surface of the body from above the anus to the posterior portion of the head. A third frog (B.M. 1961.1193) was infested by a 9·0 mm. leech which lay beneath the skin of the ventral surface of the humerus and pectoral region.

Nematodes were recovered from the stomach and ileum of one frog and the ileum of another, whilst the bladders of 45 per cent. of the series were infested with trematodes. The total number of trematodes recovered was 69.

The natives refer to this species as either "*Ken-dangma*" or "*Boo-ganda*".

Hyla becki was so named as an acknowledgment to the collections made in New Guinea by Sgt. W. M. Beck.

Hyla darlingtoni Loveridge

Hyla darlingtoni Loveridge, 1945, *Proc. biol. Soc. Wash.*, **58**, p. 53.

Material: 21 adult ♂♂, 10 adult ♀♀, 1 juvenile, 1 tadpole. Austral. Mus. R.16839-16844; B.M. 1961.1126-1149, 1150 (tadpole); K.T.C. F.5.021, 024.

Description: Head as broad as long, length of subacuminate snout approximately twice the horizontal diameter of eye; pupil horizontal or circular in life; diameter of tympanum exceeds three-quarters that of eye; vomerine teeth

situated in two series directly between choanae and separated by a distance equal to the length of one of them; outer finger three-quarters webbed, connected to disc by narrow fringe; heel of adpressed hind limb extends to anterior border of eye; skin of body smooth above, granular beneath. Male possesses a raised nuptial pad (Fig. 3) which is pigmented (17 specimens) or unpigmented (3).

Body Length: 34·4-43·7 mm. ♂ ♂; 42·0-47·1 mm. ♀ ♀; 29·0 mm. juvenile.

Colour in Life: Ground colour of dorsal and lateral surfaces of body and limbs orange brown (24), dull sepia (4) or grey (3); narrow, pale mid-vertebral stripe extends from tip of snout to sacrum in first-mentioned form, but continues to vent in others; head and skin covering transverse processes of vertebrae dark brown (20) or black (11). Behind knee and at groin of adults are large irregular black patches variegated with brilliant orange. In the juvenile the patches are brown variegated with yellow and a similar mark occurs at base of forearm. In adults the latter is replaced by a few pink spots.

Throat lightly pigmented with brown (23) or dull yellow (8); thorax, abdomen and limbs immaculate cream (27) or pale pink (4).

The colour in preservative is similar to the description of the type specimens (Loveridge, 1948).

Locality: All but one of the series were collected at Nondugl (5,700 ft.) on 24th-25th March, 1960. The exception was taken at Mintima, near Kundiawa in the Wahgi Valley, and approximately 20 miles south-east of Nondugl, at 6,000 ft. on 1.6.60.

Remarks: Three plates are included in the description of *Nyctimystes flavomaculata* (Forcart, 1953), a species which is clearly conspecific with *H. darlingtoni*.

Habitat: *Hyla darlingtoni* is an arboreal species and by far the most abundant frog found in the Wahgi Valley. It was recorded upon the leaves of coffee trees (*Caffea typica*) and giant tree ferns (*Cyathea contaminans*), and in the moist spaces at the base of leaves of Mauritius Hemp, banana and *Pandanus* sp.

Habits: A total of 132 food items were recovered from the stomachs of 53 specimens collected, but not retained, during the period 22.1.60-28.3.60. The nature of these food items has been tabulated elsewhere (Tyler, in press).

The call consists of a series of 20 to 30 separate notes over a total duration of from three to seven seconds. It starts on a high note and ends on a low one. The duration of each individual note is brief at the commencement of the call, but noticeably extended at the end.

Calling became most intense towards the end of March and it was noticed that there were two separate choruses or periods of activity. The first and most vociferous occurred from 9.00 p.m. to midnight and the second from 1.00 a.m. to 3.00 a.m. At the height of a chorus, individuals would occasionally emit a laborious squeak, quickly repeated two or three times, but the function of this sound could not be determined.

Development: The number of ripe ova dissected from gravid specimens collected in February, 1960, was found to exceed 400. Diameter of ovum 1·5 mm.; upper pole black, lower pole pale cream.

Tadpoles were collected in April from shallow ponds and blocked drainage ditches in native gardens on the Wahgi Plains, at altitudes of 5,000-5,500 ft. Insufficient numbers were obtained to warrant the description of anything but the dentition, which showed very little variation between individuals.

Larval Mouthparts:

Row I Upper labials—complete row.
Row II Upper labials—wide median gap.
Horny beak—undivided; deep; strongly serrate.
Row I Lower labials—complete row.
Row II Lower labials—complete row.
Row III Lower labials—narrow median gap.

The maximum length (body + tail) of the tadpoles examined was 58 mm. Eruption of hindlimbs occurred after a reduction to a maximum total length of approximately 53 mm.

The feeding habits of tadpoles were observed on several occasions. They were seen foraging amongst organic debris on the floor of the ponds and buried themselves in this material when disturbed. Intestinal contents were found to consist of decomposing plant material and silt.

Distribution: Only recorded from Mt. Wilhelm, where the type series was taken at 5,000-7,000 ft., Mt. Hagen and intermediate localities in the Wahgi Valley.

Notes: The only record of predation upon adult *H. darlingtoni* is the observation made by the writer on 15.3.60, when a Colubrid snake, *Ahaetulla calligaster calligaster* (Gunther) was found on a frond of *Cyathea contaminans* ingesting a 45 mm. frog.

The introduction of small fish (*Gambusia* sp.—live-bearing tooth carps of the family Poeciliidae) into ponds in the Wahgi Valley in 1946 in an attempt to eradicate mosquito larvae, has probably reduced the endemic population of *H. darlingtoni*. Mr. Shaw Mayer of the Hallstrom Livestock and Fauna Station informed the writer that spawn and large numbers of tadpoles, which were probably *H. darlingtoni*, were seen prior to the introduction at Nondugl (? in 1952).

A frog collected at Mintima on 1.6.60 was found to be the host of an ectoparasitic leech.

The native names of *darlingtoni* are "*Warr-sip*" in the vicinity of Nondugl, and "*Nar-goon-gar*" by natives living in the Chimbu region.

The specific name honours the collector, Capt. P. J. Darlington.

Hyla iris Tyler

Hyla iris Tyler, 1962, *Rec. S. Aust. Mus.*, **14** (2), p. 253.

Hyla iris is a pygmy species recently described from a series of 26 specimens collected on the Wahgi-Sepik Divide near Nondugl. Data in the present paper are restricted to ecological and biological observations excluded from the description of the type series.

Habitat: This species was found in low vegetation beside streams in moss-forest. A single specimen (B.M. 1961.1226) was collected at the summit of a pass at 9,500 ft., at least 1,500 ft. above the source of the nearest stream.

Development: Spawning was found to occur in April. The ova are pale green in colour, and measure approximately 2·5 mm. in diameter when freshly laid. There are two vitelline membranes and the diameter of the outer is approximately 4 mm. The eggs are laid in either hemispherical masses of clear albumen on the upper surface of leaves of trees overhanging water, or in ovoid-shaped masses around the stems of ferns or sturdy grasses at the edge of streams. In 26 clumps of eggs which were examined during the period 15-19.4.60

the number of ova per clump was as follows: Range =4-37; mean = 14. The largest hemispherical clump was almost 50 mm. in diameter, whilst the largest ovoid clump had a length of 75 mm. and breadth of 50 mm.

The first cleavage plain was visible after 24 hours, and it was noticed that several of the embryos rotated within the vitelline membranes during this period. Rotation was on no definite axis, and continued for up to three hours.

Within three days the embryos were clearly differentiated into head, body and tail. At this stage the head, tail and dorsal surface of the body had assumed a pale brown colour, but the ventral surface remained green.

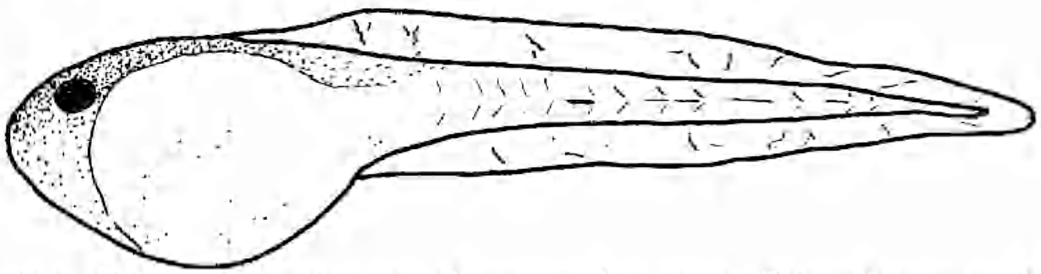

Fig. 6. Tadpole of *Hyla iris* at time of emergence from spawn. Distance between mouth and vent = 3·5 mm.; vent-tip of tail = 6·5 mm.

Hatching occurred at approximately fourteen days, by which stage the tadpoles had grown to a length of 10 mm. (head + body = 3·5 mm., tail = 6·5 mm.); the outer vitelline membranes were cloudy white, and their diameter had increased to 12 mm. At the time of hatching the tadpoles possessed internal gills and strong muscular tails (Fig. 7). Their dorsal colouration had darkened to black and the ventral surface to a paler green.

The hatching tadpoles wriggled their way to the surface of the spawn mass and either dropped into the streams or were washed there by rain.

A culture of tadpoles was reared on filamentous algae for a further four weeks, and observations were unfortunately terminated before the eruption of the hindlimbs. One tadpole was preserved as B.M. 1961.1227 and a description of this specimen is as follows:

Mouth prominent, raised to form manubrium; papillae on lateral and anterior borders, but absent from posterior border which is associated with marginal upper labial teeth. Upper labials consisting of two rows, of which the second is interrupted by wide median gap; lower labials in three rows; second and third complete, first with narrow gap.

Notes: The native name for *H. iris* is "*Kenda-koo-baganda*".

Green ova have previously been recorded for *Megalixalus laevis* of Cameroon, and *Agalychnis moreletti* of El Salvador, Central America.

Hyla micromembrana new species

Holotype: S.A.M. R.4150; ♀ collected at an elevation of 7,500 ft. on Mt. Podamp, Wahgi-Sepik Divide, near Nondugl on April 1st, 1960.

Diagnosis: A moderately sized species closely allied to *Hyla pratti*, possessing only basal webbing between the fingers and fully webbed toes. The specific name refers to the condition of the finger webbing.

Description of Holotype: Vomerine teeth in two oblique series between the oval choanae, separated from each other by one-quarter and from the choanae by two-thirds of the length of one of them; tongue two-thirds as wide as mouth opening, almost circular, its posterior border emarginate; snout large, rounded when viewed from above, almost blunt in profile; nares lateral, their distance from end of snout almost equal to that from eyes. Canthus rostralis prominent, strongly rounded; loreal region oblique and concave. Eye large, prominent, its diameter slightly greater than its distance from naris, pupil horizontal; interorbital distance less than width of upper eyelid, which is slightly greater than internarial distance. Tympanum distinct, annulus clearly visible, almost one-third diameter of eye, separated from eye by distance greater than its own diameter. Second, third and fourth fingers webbed at base, first free. Fingers in decreasing order of length: $3 > 4 > 2 > 1$. Disc of first finger smaller than tympanum, second, third and fourth slightly greater. Second, third and fourth toes webbed to penultimate phalanx, continuing to disc as fringe; first half-webbed, fourth two-thirds webbed. Toes in decreasing order of length $4 > 5 = 3 > 2 > 1$, discs approximately equal to tympanum; a small oval outer but no inner metatarsal tubercle.

Body not elongate, in post-axillary region a little narrower than greatest width of head; when hindlimb is adpressed, heel extends beyond tip of snout; when limbs are laid along the sides, knee and elbows meet; when hindlimbs are bent at right-angles to body the heels overlap considerably. Skin of upper parts smooth with few scattered warts, particularly on upper eyelids. Strong fold of skin extends from posterior corner of eye to between the angle of the jaw and the forelimb, hiding upper border of tympanum; ventral surfaces granular, particularly upon the thighs. Skin of head not co-ossified with skull. Female gravid.

Dimensions: Head and body 51·5 mm.; head length 15 mm.; head breadth 17 mm.; femur 29 mm.; tibia 34 mm.

Colour in Alcohol: Dorsal surface a uniform very dark slate, ventral surface grey variegated with dark violet, particularly on the throat.

Colour in Life: Dorsal surface dark chocolate, flecked with green on laterals and upon discs of digits. Ventral surface violet flecked with slate blue, grey and brown.

Variation: Paratypes—Five adult ♀ ♀—Austral. Mus. R.17991-17992; B.M. 1962.154-156.

Two of the paratypes were collected at Bilikep, 6,300 ft. on the Wahgi-Sepik Divide on 26.3.60, and the remainder with the holotype on 1.4.60.

Body Length: 45·0-51·5 mm.

The paratypes conform closely to the description of the holotype. The pupil of one specimen was vertical in life, but there is no palpebral venation. The distance between eye and naris is approximately one and one-quarter to one and one-half of the internarial distance; the distance between eye and naris is equal to (1 specimen), or very slightly greater than, the distance between tip of snout and naris (4). TL/S-V = 0·58-0·66 (mean = 0·604).

The dorsal surface of the skin is pustulose in all specimens and large tubercles are present on the upper eyelids.

Comparison with Other Species: The reduced webbing between the fingers and the proportions of the head will serve to distinguish *H. micromembrana*

from *H. mintima*, and all of the species compared with *mintima* in the account of that species except *H. pratti* and *H. wollastoni* Boulenger. The tympanum of *pratti* is nearly half the diameter of the eye, whereas in *micromembrana* it is less than one-third. The toes of *pratti* are only three-quarters webbed as opposed to fully webbed, whilst the foot lacks an outer metatarsal tubercle.

Hyla mintima new species

Holotype: S.A.M. R.4151; ♂ collected at Mintima (lat. 5°57'S., long. 144°54'E.), Chimbu Region, at 6,000 ft., on June 1st, 1960.

Diagnosis: A moderately sized species closely related to *Hyla montana* Peters and Doria, with a small tympanum, reduced webbing between the fingers and extensively webbed toes. The specific name is that of the type locality.

Description of Holotype: Vomerine teeth in two oblique series between the rounded choanae, separated from each other and the choanae by a distance approximately two-thirds the length of one of them; tongue one-half as wide as mouth opening, almost circular, its posterior border not emarginate; snout large, rounded when viewed from above, strongly convex in profile, the upper jaw extending considerably beyond lower; nares lateral, their distance from end of snout slightly less than that from eye. Canthus rostralis prominent, slightly concave; loreal region oblique. Eye large, prominent, its diameter slightly greater than its distance from naris, pupil horizontal; interorbital distance almost equal to width of upper eyelid, which is relatively wide and slightly greater than internarial distance. Tympanum indistinct, annulus hardly visible, almost one-third the diameter of eye, separated from eye by distance greater than its own diameter.

Second finger webbed at base, third and fourth less than one-third webbed, first free. Fingers in decreasing order of length 3 > 4 > 2 > 1. Disc of first finger equal to tympanum, second, third and fourth considerably larger. Second, third and fifth toes webbed to disc, first and fourth to penultimate phalanx and continuing to disc as fringe. Toes in decreasing order of length 4 > 5 = 3 > 2 > 1, disc of second covering tympanic area; a distinct oval inner, but no outer metatarsal tubercle. A row of small tubercles on tarsus, a distinct fold on outer edge of fifth toe; a distinct crenulated fold on outer edge of forearm continuing as ridge along fourth finger.

Body not elongate, in post-axillary region a little narrower than greatest width of head; when hindlimb is adpressed, heel reaches naris; when limbs are laid along the sides, knee and elbow overlap considerably; when hindlimbs are bent at right-angles to body, heels overlap slightly. Skin of upper parts of head, body and limbs granular; strong fold of skin extends from posterior corner of eye to above insertion of forelimbs, hiding upper margin of tympanum. Abdomen and thighs coarsely granular, throat and thorax slightly so. Skin of head not co-ossified with skull. Male with nuptial pads (Fig. 3) and vocal sac.

Dimensions: Head and body 55·6 mm.; head length 21·5 mm.; head width 22·2 mm.; tibia 29 mm.

Colour in Alcohol: Dorsal surface deep plumbeous; grey beneath darkening posteriorly.

Colour in Life: Dorsal surface a very dark green. Side of head similar, with a dusky gold patch in the shape of an isosceles triangle beneath eye. Sides of body dark green spotted with gold on dorso-laterals and white on ventro-laterals. Throat and thorax pale slate grey spotted with white; abdomen and ventral surface of limbs deep violet stippled with white and cream.

Variation: Paratypes—Four adult ♂♂—Austral. Mus. R.17993-17994; B.M. 1962.157-158.

The paratypes were collected at the type locality on 1.6.60.

Body Length: 52·0-53·0 mm. TL/S-V = 0·55-0·61 (mean = 0·576).

The horizontal diameter of the eye is always less than the interorbital diameter, whilst distance between eye and naris is one and one-half to one and three-quarters of the internarial distance. The distance from eye to naris is greater than (approximately one and one-quarter) that between naris and the medial tip of the snout.

Colouration of the paratypes in alcohol and in life is similar to that of the holotype.

Comparison with Other Species: There are few New Guinea *Hyla* which possess the combination of the following characters: a tympanum which is less than half of the eye diameter; outer fingers with webbing which is either basal or extends for no more than one-third of the length of the digit, and vomerine teeth. Species fulfilling these requirements are *H. albolabris* Wandoleeck, *H. angiana*, *H. arfakiana*, *H. montana*, *H. pratti* and *H. wollastoni*. *Hyla mintima* can be distinguished from most of these species by the extent of the webbing between the fingers and toes. *Hyla albolabris* has narrowly webbed toes, whilst they are fully webbed in *mintima*; the fingers of *wollastoni* have a very narrow basal webbing as compared to up to one-third webbing in *mintima*. The remaining four species all occur in the Central Highlands. *Hyla angiana* has one-third webbing of the fingers, but the head is far more depressed, with the interorbital breadth clearly greater than an upper eyelid and the colouration bears not the slightest resemblance to *mintima*; *H. arfakiana* has the first toe nearly free and only two-thirds webbing between the remainder, whilst *pratti* has only basal webbing between the second, third and fourth fingers.

The webbing of the hands and feet of *mintima* is almost identical to *montana*, to which it is apparently most closely allied. The latter has a broad head and larger tympanum. The interorbital space is greater than the width of an upper eyelid, whilst it is narrower in *mintima*. The disc of the first finger of *montana* is smaller than the tympanum, whilst the disk of *mintima* covers the tympanum. The colour patterns of the two species are quite distinct.

Hyla montana Peters and Doria

Hyla (*Litoria*) *montana* Peters and Doria, 1878, *Ann. Mus. Stor. nat. Genova*, **13**, p. 423.

Material: Four adult ♂♂, two adult ♀♀. Austral. Mus. R.17989-17990; B.M. 1962.150-153.

Description: The vomerine teeth of the present series differ from the diagnosis of van Kampen (1923) in that they are situated in oblique instead of transverse rows. In four specimens they are directly between the choanae and between the posterior borders of the choanae in the fifth. The dermal folds on the back of the forearm occur as single rows of tubercles instead of a continuous ridge, and there is no inner metatarsal tubercle. TL/S-V = 0·55-0·60 (mean = 0·573).

Body length = 45·0-57·0 mm. ♂♂; 72·0-75·1 mm. ♀♀. Male with a nuptial pad on the first finger (Fig. 3).

The colour in life is a sandy brown on the dorsal surface, with pale green patches before and beneath the eyes and upon the scapulae. The ventral surface is pale grey suffused with pink. Van Kampen states colour in life to be

"yellowish green". Despite this discrepancy there is such slight variation between the morphology of the present series and the elaborate description of the types that their identity as *H. montana* is made without reservation.

Locality: Collected upon the Wahgi-Sepik Divide within ten miles of Nondugl during the period 26.3.60-9.6.60. Altitude range: 6,400-8,700 ft.

Distribution: *Hyla montana*, as its specific name implies, is a montane species. The type locality is the Arfak Mountains in Dutch New Guinea, and other records include Humboldt Bay north of the type locality (van Kampen, 1914), and Toromanbanau in the Bismarck Mountains of the Australian Trusteeship Territory, by Loveridge (1948). There are no previous records of its occurrence in the Central Highlands.

Notes: One of the females (B.M. 1962.153) is gravid. The ova are unpigmented and approximately 2·5 mm. in diameter.

The native vernacular name of this species is "*Pee-un-day*".

DEVELOPMENT

Information on the development of *Nyctimystes* spp. is very limited. Zweifel (1958) examined gravid females of twelve species and reported that the ova often exceeded 2 mm. in diameter and in one species exceeded 3 mm. With the exception of *N. ruepelli* (Boettger) the eggs were unpigmented. Parker (1936) described the tadpoles of *N. montana* Parker and *N. semipalmata* and suggested that the dorso-lateral flattening of the bodies and the suctorial mouths which were common to these species might characterise other members of the genus.

Numerous clumps of spawn referable to the genera *Nyctimystes* and *Hyla* were found by the writer in February and March at elevations of 6,000-7,000 ft., but few could be associated with particular species. The clumps were situated either between stones at the waterline where they lay in water less than one inch deep or adhering to the undersurface of flat stones submerged in torrents. Water temperatures in these situations fluctuated between 13° C. and 17° C. The ova were unpigmented with diameters of 2·5-4·0 mm. The albumen surrounding them was gelatinous and so firm that it could be cut with a knife. Diameters of the outer vitelline membranes of individual eggs was 4·0-9·0 mm., and the number of eggs per clump averaged approximately 200. It was considered that fertilisation of spawn laid beneath stones could not have occurred at the site of the final deposition. Many of the clumps at the waterline were infested with dipterous larvae which devoured the ova. A note on these observations has been published elsewhere (Tyler, 1962b).

All tadpoles found in the mountain torrents were similar to those Parker described. Although the tadpoles of all *Nyctimystes* may prove to share those characteristics, the fact that *H. angularis* tadpoles are similarly adapted to montane conditions indicates that the genera cannot be distinguished by their gross morphological form.

In referring *Nyctimystes loveridgei* Neil to *Hyla*, Zweifel comments that the ova are "typical of *Hyla*, being small, with a dark animal hemisphere". Although the ova of *H. darlingtoni* fit this description, those of *H. iris* are green and *H. angiana*, *H. angularis*, *H. becki*, *H. micromembrana* and *H. montana* are unpigmented. Thus the eggs of *H. darlingtoni* may be typical of the majority of species in this widely distributed genus, but they are apparently atypical when compared with other highland species in both appearance and site of deposition. The selection of static or slowly moving water for the deposition of

spawn by *H. darlingtoni* has prevented this species from establishing itself at higher altitudes, but the remaining *Hyla* of the Central Highlands appear to be as well adapted to montane conditions as are *Nyctimystes*.

The arboreal spawning habits of *H. iris* are by no means unique. Arboreal spawning has not previously been reported from the Papuan region and the closest parallel is probably exhibited by Neotropical frogs. Noble (1927) states that all *Phyllomedusa* spp. deposit spawn on leaves of foliage above pools and, referring to the field notes of Mr. C. M. Breder, Jr., reported similar sites for a *Centronella* species in Panama believed to be *C. parabambae*. Dunn (1924) reported that *H. uranochroa* from the same region laid eggs on leaves above streams.

THE STATUS OF THE GENUS *NYCTIMYSTES* WITH NOTES ON THE APPEARANCE OR ABSENCE OF GENERIC CHARACTERISTICS IN LIFE

Stejneger (1916) erected the genus *Nyctimystes* for New Guinea Hylidae which had been referred to the South American genus *Nyctimantis* by Boulenger (1897, 1914) on the grounds that he considered the faunae of these regions could not be closely related. Noble (1931) suppressed *Nyctimystes* and referred the species back to *Nyctimantis*. This decision was reversed by Parker (1936), a move subsequently supported by Zweifel (1958). It is of interest to note that several of the genera sharing either the palpebral venation or the vertical pupil which, when together in New Guinea Hylids are diagnostic of *Nyctimystes*, are in fact South American. Although not disputing the opinion of Parker that *Nyctimystes* represents a homogeneous group of true generic status, there are occasional discrepancies between the appearance of living frogs and the generic definition of Zweifel (*loc. cit.*) which was based on preserved specimens. For example, the pupil of live *N. narinosa* is a horizontal slit, and is not vertical in any of the series of that species discussed in this paper.

Although tropical American frogs of the genus *Phyllomedusa*, with which *Nyctimystes* has been compared, and which includes species possessing the salient characters of the latter, may be distinguished by the form of hands and feet; habits are similar. *Nyctimystes* has very sensitive digits which are well suited for grasping narrow branches, but the first finger is not opposable as in the former genus.

The palpebral venations of living *Nyctimystes* are more distinct than in preserved specimens, and have a metallic appearance in several species.

Mature males in the present collection and the type series of *N. gularis* possess a nuptial pad which extends further proximally, than in the *Hyla* spp. examined. This may prove to be a further characteristic for distinguishing members of the two genera. The proximal border of the nuptial pad of *Nyctimystes* covers the phalango-metacarpal joint, and occasionally the distal end of the phalanx. In *Hyla* it terminates on the proximal head of the metacarpal.

DISTRIBUTION

Of the eleven members of the Hylidae which occur in the Central Highlands, no less than six must currently be regarded as endemic to this area. That such a proportion of the species should be regarded as endemic is not so surprising when allowance is made for the fact that much of the vast area of land which separates the Central Highlands from the northern and southern coastal belts is

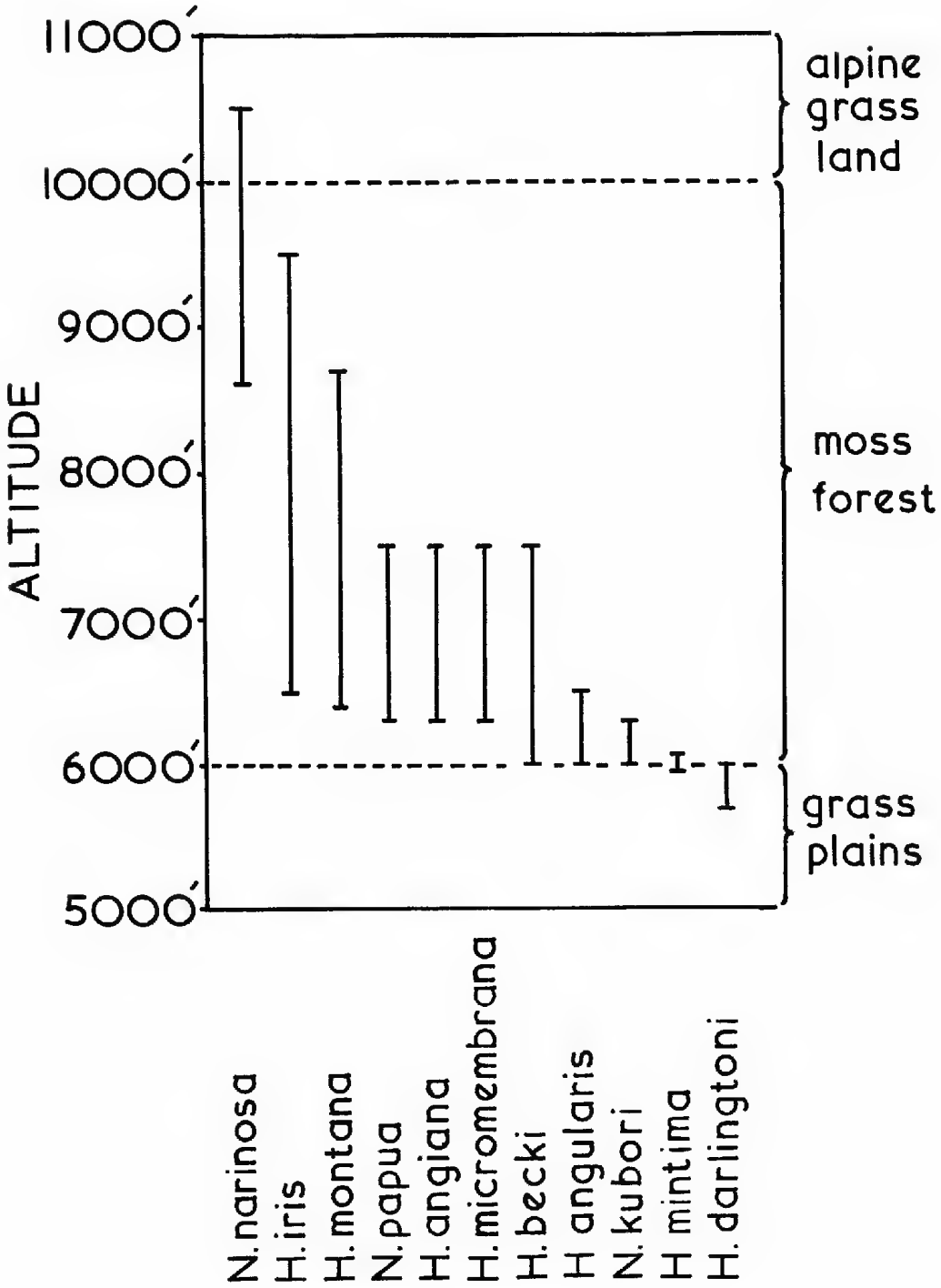

Fig. 7. Altitudinal distribution of the Hylidae of the Central Highlands. (Based on the writer's observations on the Wahgi-Sepik Divide.)

virtually unexplored and the herpetofauna therefore completely unknown. Locality records indicate that the non-endemic species, *Nyctimystes papua*, *Hyla angiana*, *H. arfakiana*, *H. montana* and *H. pratti*, select a montane habitat and have not been collected at altitudes lower than 5,000 ft.

Distribution may be partly associated with climatic conditions. For example, specimens of the distinctive *N. humeralis* (Boulenger) were collected by the writer near the source of the Jimmi River, in tropical forest at approximately 2,000 ft., yet were not found on the Wahgi-Sepik Divide ten miles to the south, which is subjected to far lower temperatures. The herpetofauna of the tropical regions surrounding the highlands will probably show greater affinities to coastal forms than to the montane.

In Fig. 8 the range of altitudes at which *Nyctimystes* and *Hyla* spp. were observed in the vicinity of Nondugl are compared.

CHECK LIST OF CENTRAL HIGHLANDS HYLIDAE

Nyctimystes kubori Zweifel
Nyctimystes narinosa Zweifel
Nyctimystes papua (Boulenger)
Hyla angiana Boulenger
Hyla angularis Loveridge
Hyla arfakiana Peters and Doria
Hyla becki Loveridge
Hyla darlingtoni Loveridge
Hyla iris Tyler
Hyla micromembrana new species
Hyla mintima new species
Hyla montana Peters and Doria
Hyla pratti Boulenger

Four specimens of *H. pratti* in the British Museum collection (B.M. 1953.1.7.49-52) were collected in 1951 at Tomba, near Mt. Hagen, by Mr. F. M. Shaw Mayer. Loveridge (1948) regarded *pratti* to be a sub-species of *H. montana* which is apparently sympatric, but there is now little doubt that they are members of a group of closely allied species, so the writer prefers to recognise their distinct specific status.

Nyctimystes flavomaculata Forcart is excluded from the above list as it has been referred to the synonymy of *H. darlingtoni* and *N. humeralis* (Boulenger) on the grounds that the specimens from the Kubor Mountains determined as this species by Zweifel (1958), are now regarded to be of a distinct and probably undescribed species (Zweifel, *in litt.*).

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